

2016 : The ultimate PHENIX Run

Results and some lessons or questions

PHENIX run16 coordinator

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The plan for run 16

Inside
symmetry
constraints
due to CEC
test

For Run 16 the PAC recommends the following (*in order of priority*):

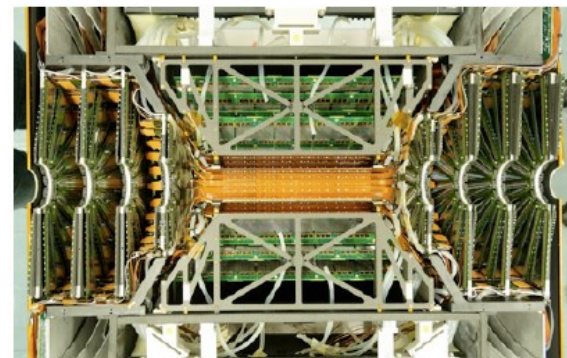
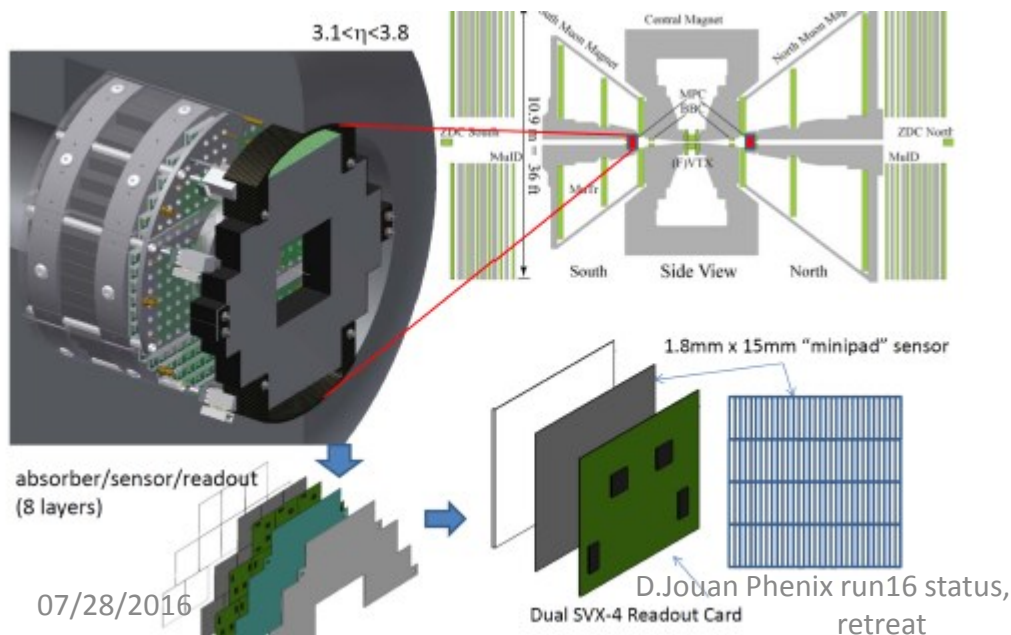
1. 10 weeks Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV
2. 5 weeks for a small system beam energy scan. This program can be realized with
 - a. Au+polarized proton collisions for a set of energies chosen among 200, 62, 39 and 20 GeV to optimize the physics output, or
 - b. d+Au collisions at 200, 62, 39, and 20 GeV
3. 2 weeks of polarized p+p collisions at $\sqrt{s} = 62$ GeV
4. Up to 4 weeks of Au+Au collisions at $\sqrt{s_{NN}} = 62$ GeV

The challenge:
will it be
possible too ?

[phenix BUP] This plan will yield
2.4 billion, 230 million, 110 million, and 7 million
central **d+Au** ($z < 10$ cm) events at energies of
200, 62, 39, 20 GeV respectively.

In the case of a shorter 15-week running time, the Au+Au run at $\sqrt{s_{NN}} = 200$ GeV remains the highest priority, in order to fulfill the mission of the STAR HFT upgrade, which is a DOE MIE project. However, this running scenario will severely limit the physics output from the PHENIX collaboration in the *last year* of the experiment.

- Last PHENIX run
- Detector: with FVTX, VTX and MPC-EX(+MPC)
- AuAu 200: Increasing the dataset, HF-> double the data, complete HF measurement
- dAu energy scan : onset of QGP in small systems



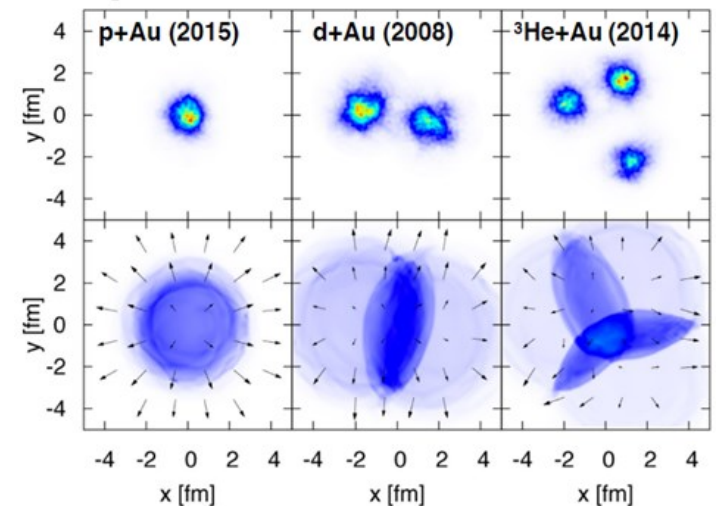
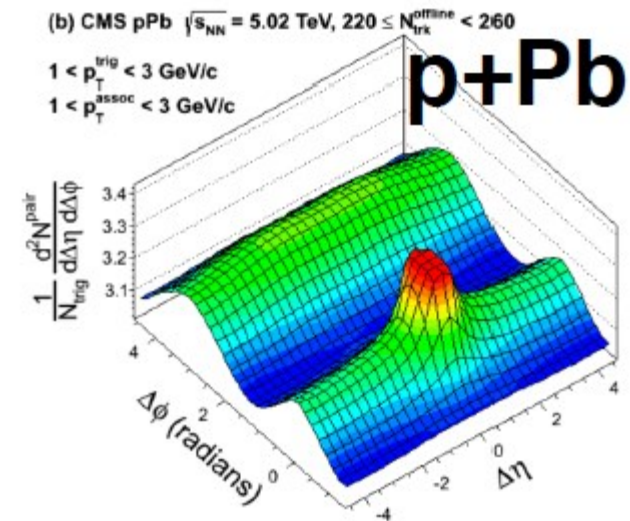
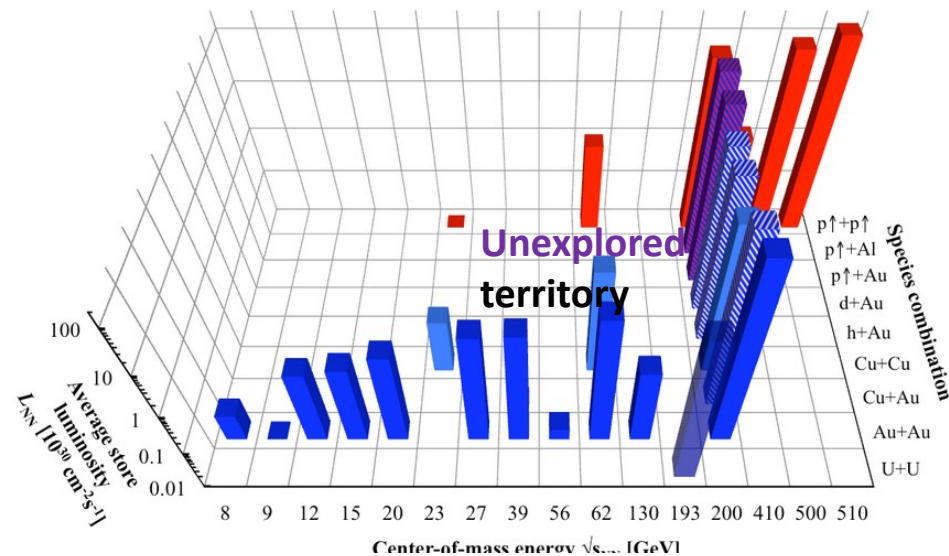
Vertex detector is necessary for Heavy Flavor studies, and can increase coverage for correlations

Long range correlations,
flow has been observed in
small systems

What is the smallest possible droplet of QGP ?

RHIC makes possible the study of the
evolution with geometry (2014, 2015 ,
and with energy! 2016 !!

RHIC energies, species combinations and luminosities (Run-1 to 15)

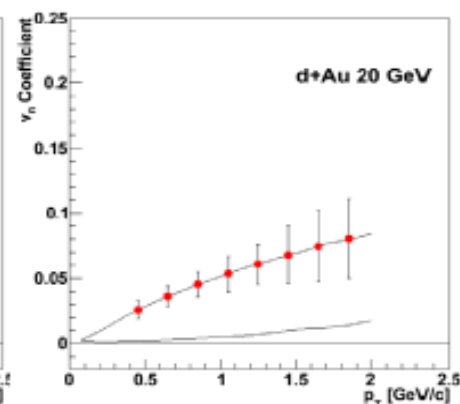
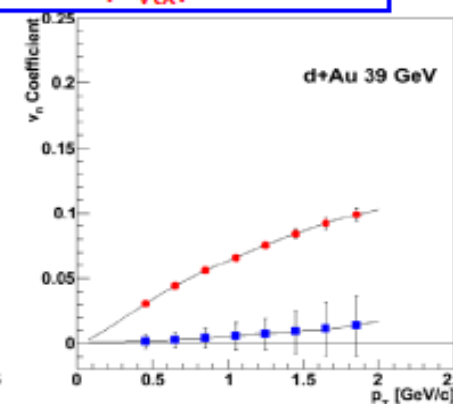
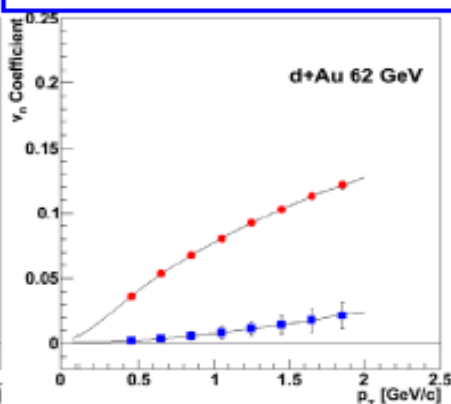
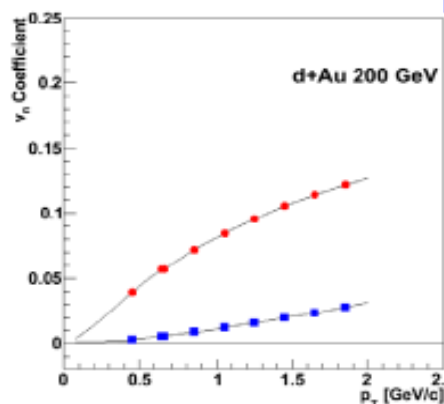


Courtesy of Björn Schenke

PAC: “unique and impressive versatility of the
RHIC accelerator in providing a variety of
collisions systems and energies.”

Projections (based on SONIC) for 5 weeks BES

0-5% central events within $|z_{\text{vtx}}| < 10$ cm



1 week, 1.6 B evts

robust baseline
 v_2 and v_3
measurements

Factor of ~20 stat
increase from Run8
FVTX improved EP

same detector
conditions=>
systematics control
in the BES

1 week, 160 M evts

All 3 lower energies for robust v_2 measurements to establish

- role of pre-equilibrium stage
- role of hadronic stage

v_3 at lower energy:
more sensitive to time
spent in QGP

Statistically significant
measurements for
both v_2 and v_3

1.5 weeks, 110M

Does v_3 collapse at lower energy ?
upper limits of v_3 can be established

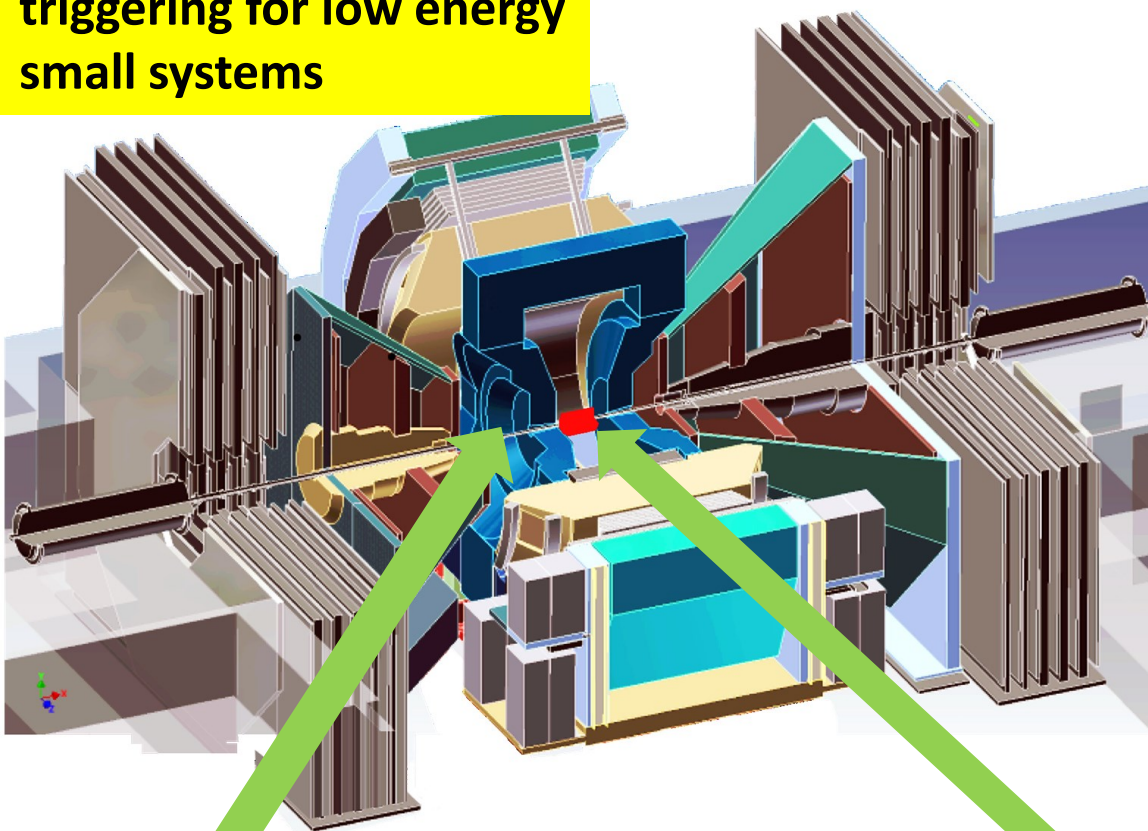
Transition region
for v_3 collapse

1.5 weeks, 9M

Largest lever arm
for v_2
measurements

The detector

No new detector, but improvements in triggering for low energy small systems



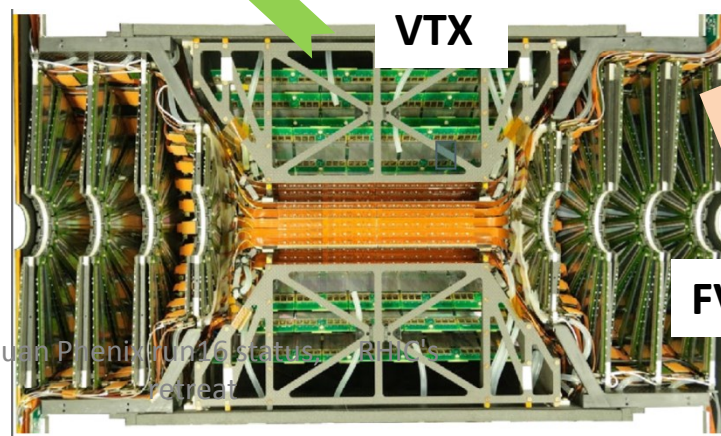
$3.1 < |\eta| < 4.$

extension of the triggers



BBC

64 Cherenkov
quartz

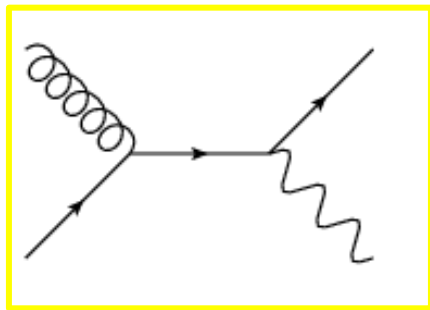


VTX

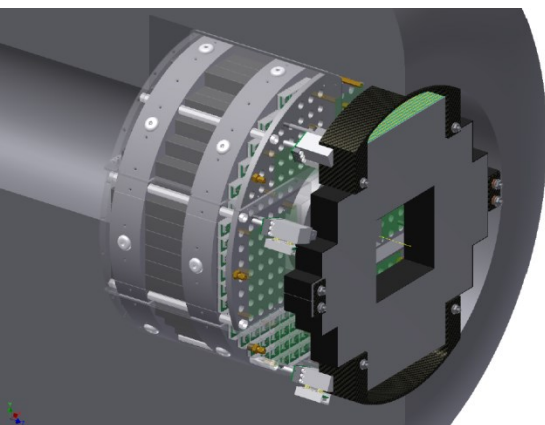
FVTX

$1.2 < |\eta| < 2.7$

Constraining Gluon nPDFs



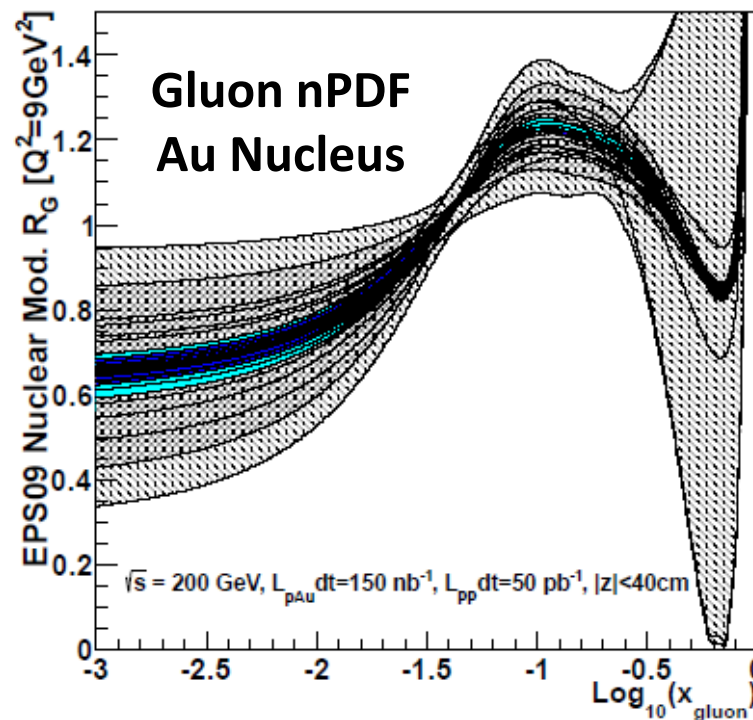
Thanks to **direct photons**
(no final interaction)



Measured by the **MPC-EX** & MPC

d side: low x Au

MPC-EX Direct Photon



Dark blue: 1-sigma

MPC EX: dAu 200 GeV

- 2016: MPCEX firmware upgrade, cooling improvement, low voltage distribution improved; MPC electronic improved
- d-Au 200 GeV becomes first priority
- Change of the order of energies, 200 GeV first (then prefires ?)

Sub-system commissioning/debugging

- Initial setup started from end 2015
- All detector subsystems installed, connected, and ready for commissioning beginning January
- Watch shifts started 12 January
- flammable gaz started the 14 January
- Full shifts started 26 January
- Data started 7 February (after blizzard)

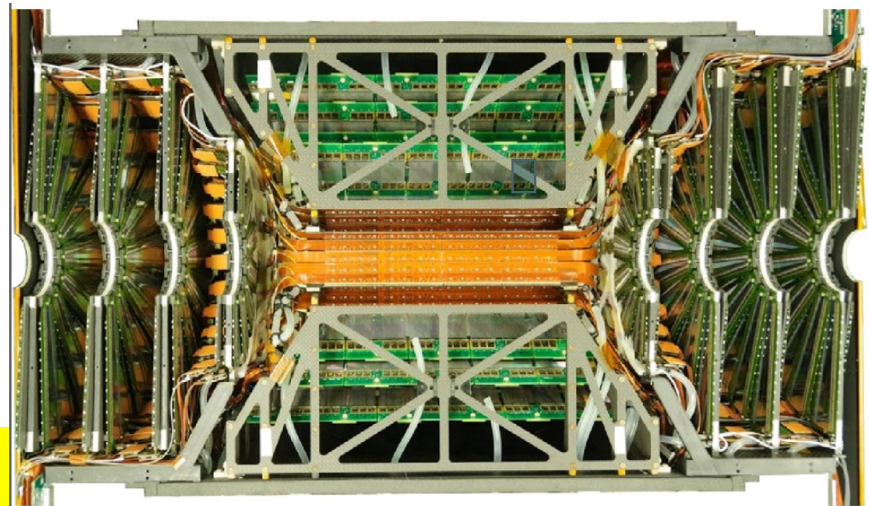
Au-Au 200 GeV

Triggering and priorities

In this AuAu 200 GeV run, the main trigger was « Minimum bias »:

The limitation comes from the DAQ maximal rate

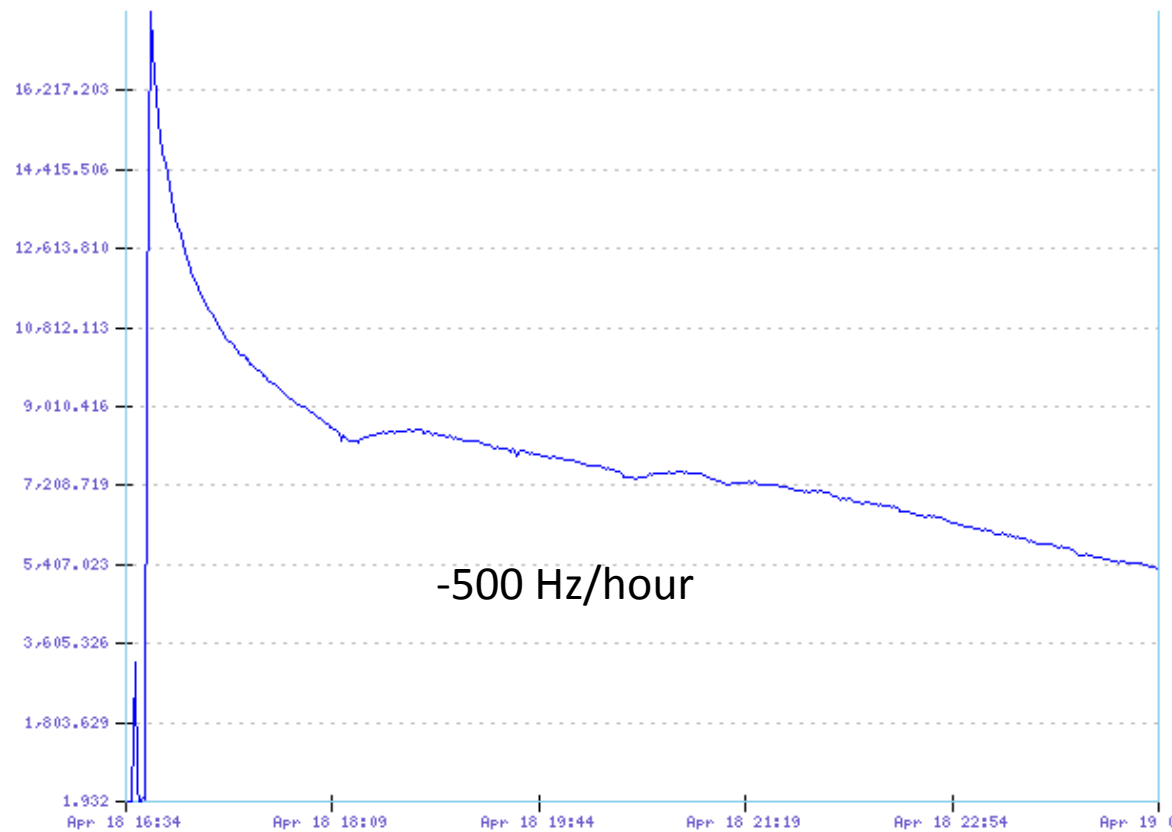
Use of VTX FVTX (HF DCA) implies being inside $\pm 10\text{cm}$



→ Phenix beam priorities for this Run:

- 1) In the $|Z| < 10\text{cm}$ vertex: **more than 7KHz AuAu collisions, up to the end of store**
- 2) highest integrated luminosity (for rare triggers)

-> can be flat, but not necessarily

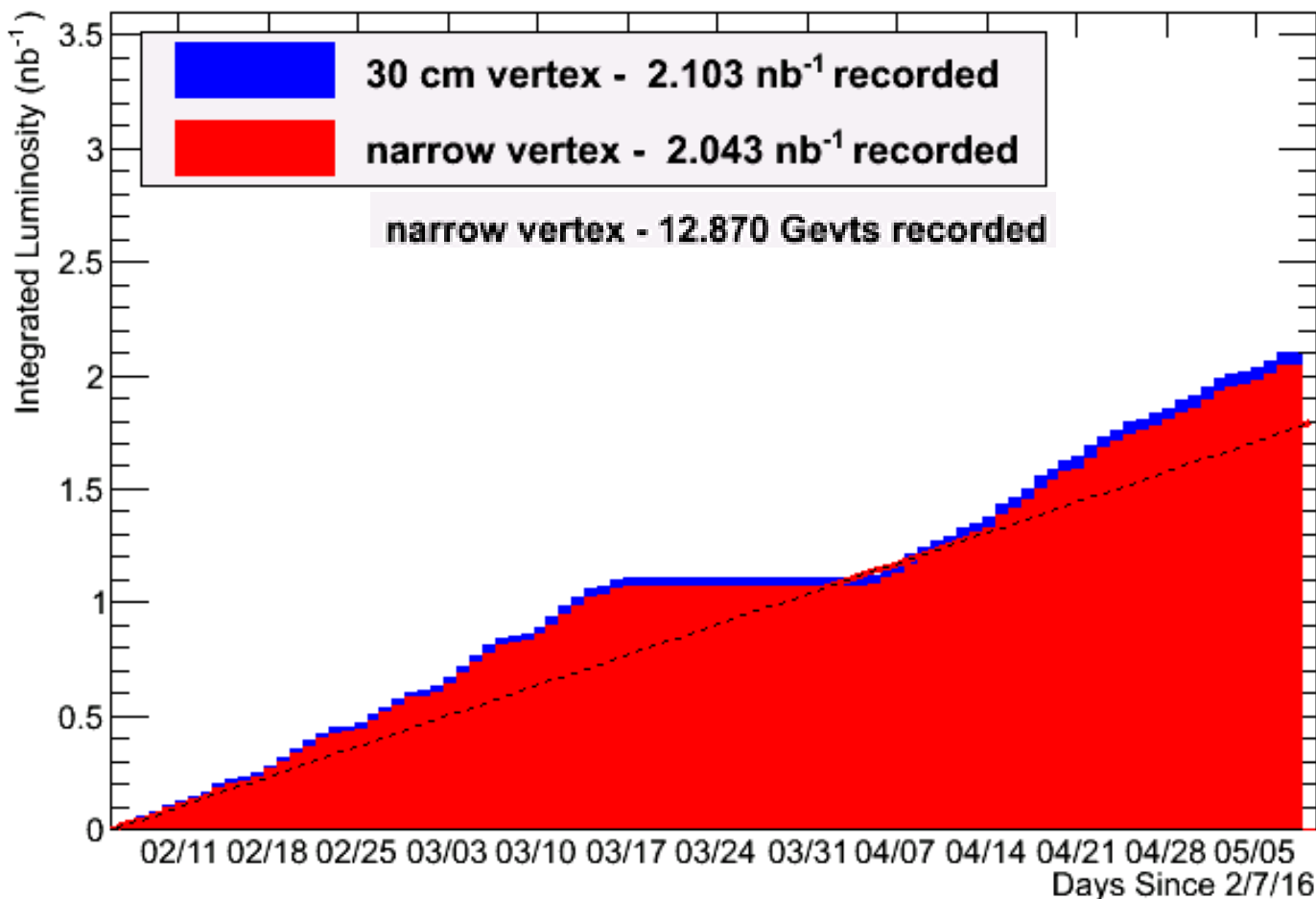


Beta star ?
 Leveling ?
 Stochastic cooling ?
 56MHz ?

Succeeding to keep the rate high : a « flat » store

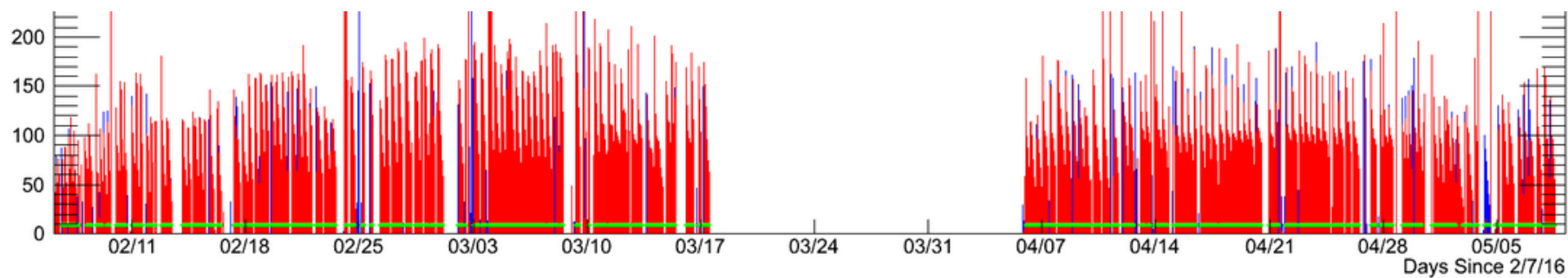
PHENIX Integr. Sampled Lumi vs Day

Mon May 9 09:01:23



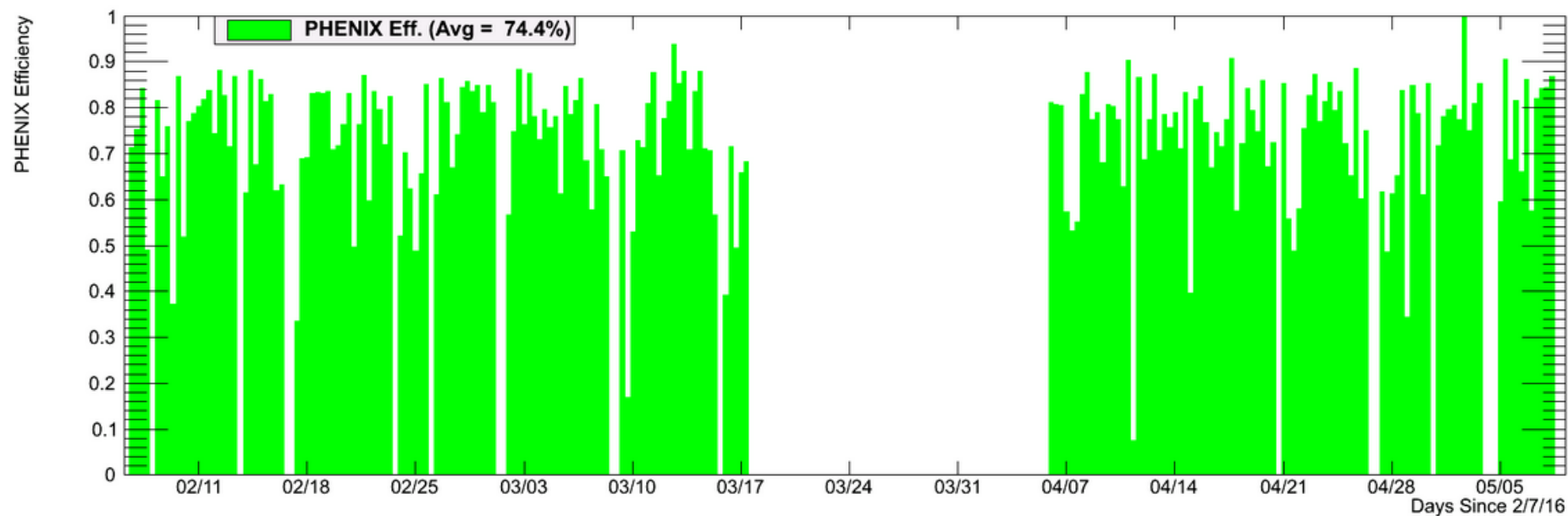
BUP goal
 1.8 nb^{-1}
 « narrow
 vertex, 5%
 central »
 Reached !

13% more
 luminosity



PHENIX Efficiency vs Day

Mon May 9



Regular data taking, good efficiency (average 75%)

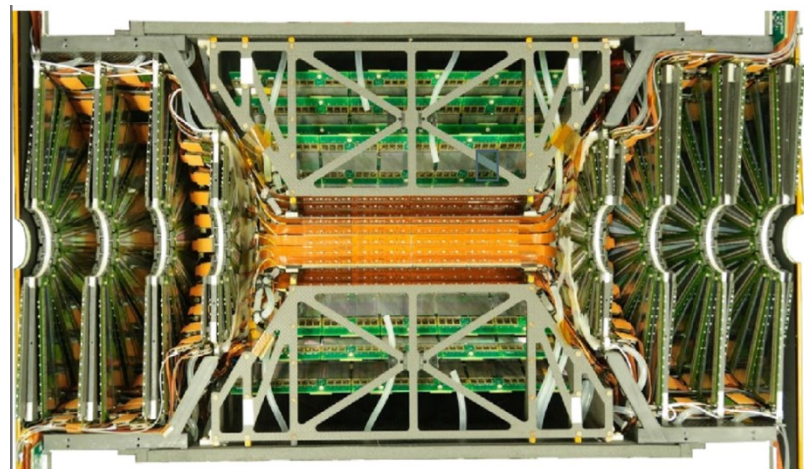
- BUP goal has been reached
- and even beyond: 13% more
- Very successful AuAu run,
- With high narrow-vertex rate delivered along almost the entire store
- 2 last days of AuAu used to repair of the drift chamber (20% acceptance) thanks to a maintenance (Mon)day
- At the end of the run, 9 more days of physics data taking have again increased the integrated luminosity

d-Au strategy

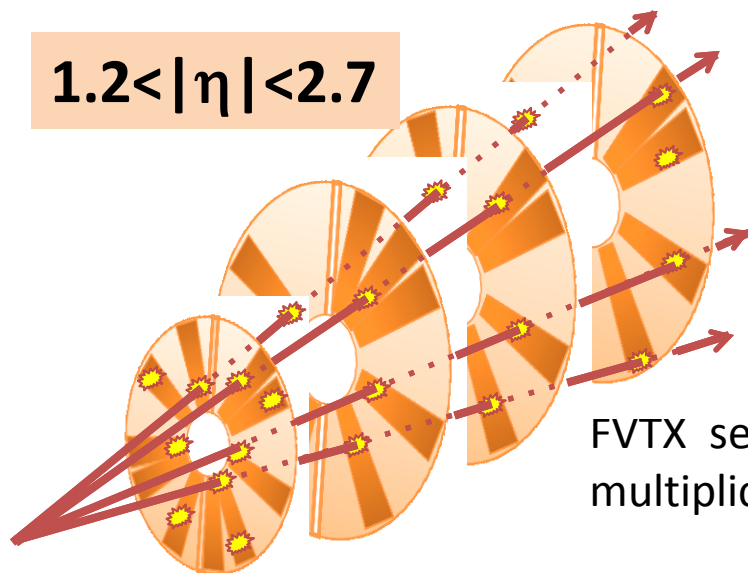
- 200 GeV became a priority thanks to an additional target : using the MPC EX to measure gluon nPDF.
- -> New sequence : 200, 64, 20, 39
- -> at 200 GeV two triggers: « min bias » (central and $Z < 10\text{cm}$) and MPC (high Pt particles).
Goal updated:
 - recorded 1B number of events « min bias »
 - delivered luminosity 0.77/nb with MPC trigger

FVTX trigger: lower rapidity, higher multiplicity

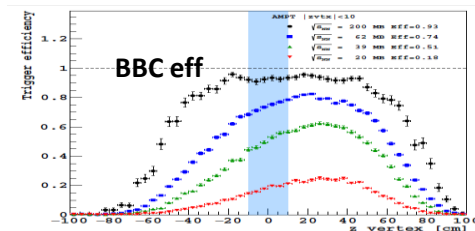
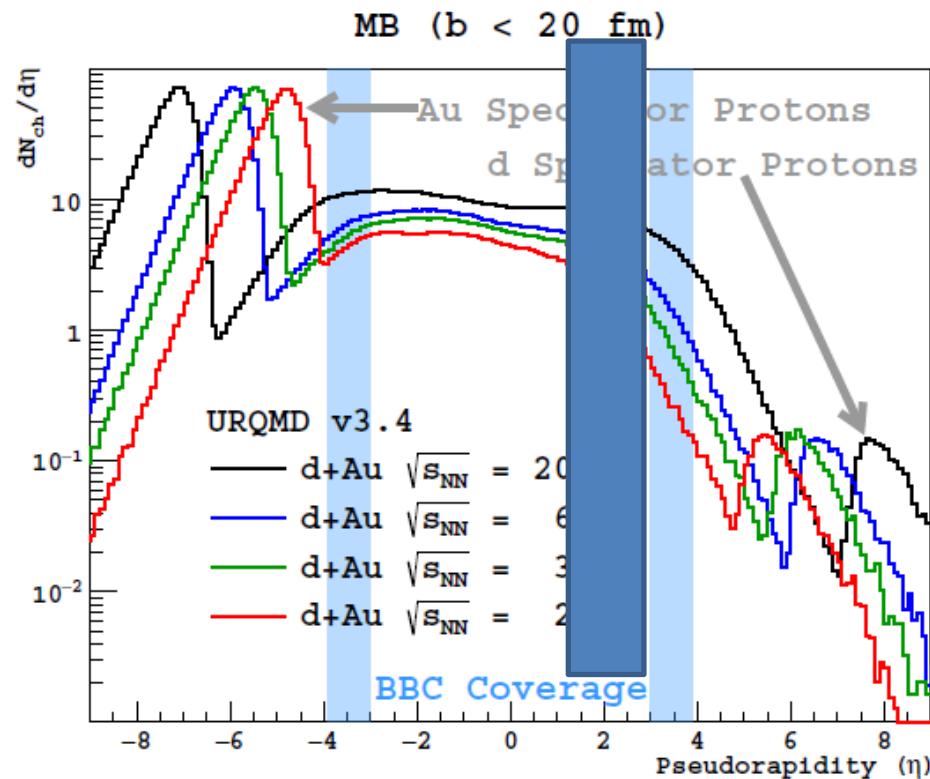
At low energy the multiplicity seen by the north (d) side is lower than 1



$$1.2 < |\eta| < 2.7$$



FVTX sees a higher multiplicity than BBC



Main triggers in d-Au

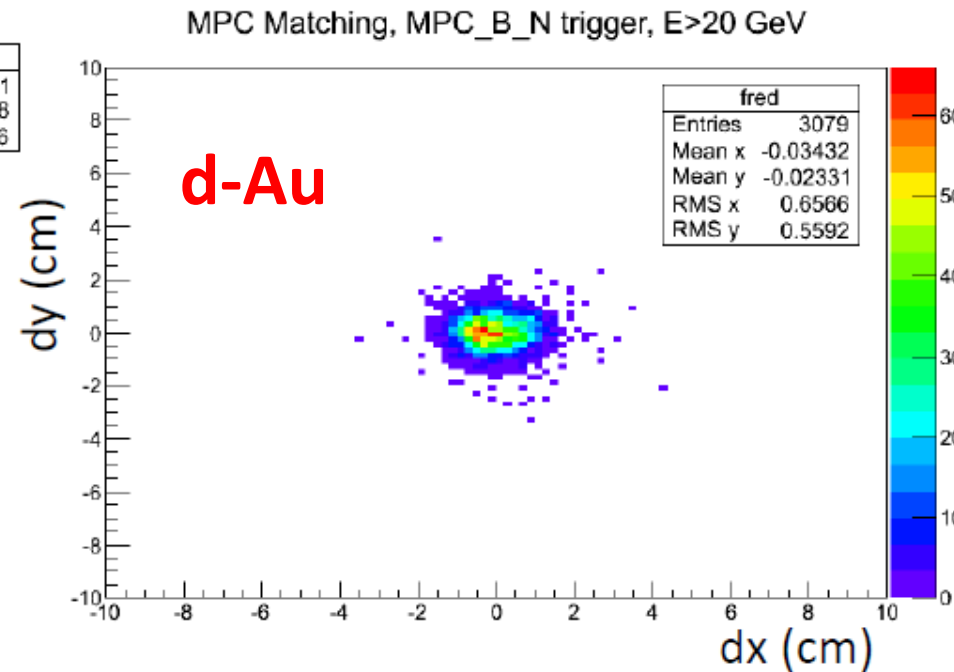
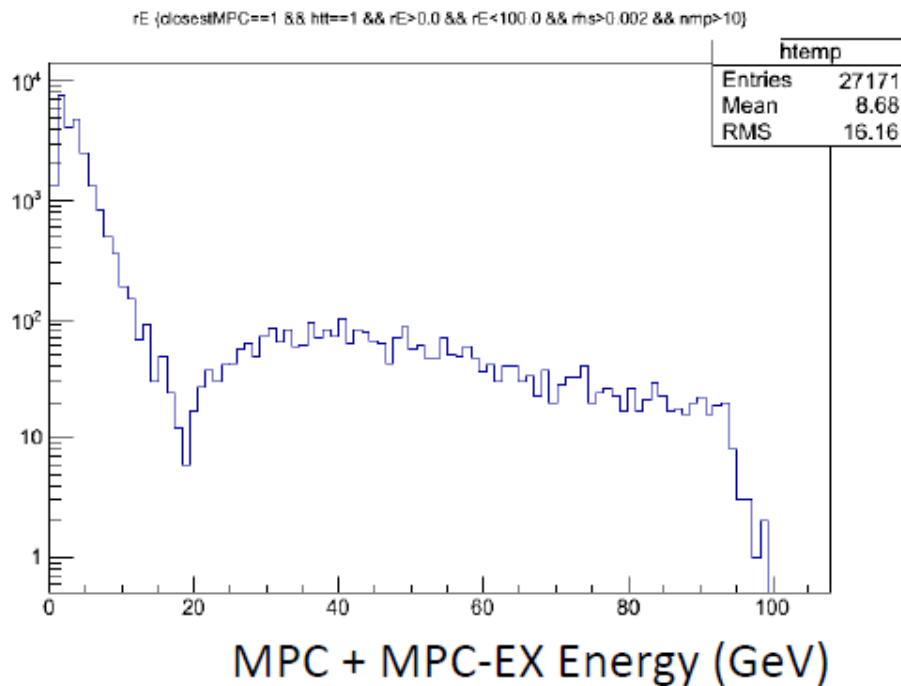
- 200 GeV: **BBC narrow** , MPC
- 62 GeV : **BBC narrow**
- 39 GeV : BBC narrow (50% eff) , **FVTX (100%)**
- 20 GeV : BBC narrow (20%eff) , **FVTX (100%)**

The goals are expressed as min bias number of events in ± 10 cm Zvertex (=« narrow ») and for 5% most central collisions. Triggers are restricted around this domain if possible and needed.

dAu 200 GeV, Good timing : PHENIX

clear correlation MPC-MPCEX

Physics runs, MPC_B_N trigger.



- MPC-EX Shower Cuts:
 - MPC-EX shower RMS (Hough space) > 0.002
 - Number of minipads in shower > 10
- Tight correlation for high energy showers (fire MPC_B_N trigger)

Overview of results and efficiencies

System	Energy (GeV)	Nevts Z<10	BUP goal	Recorded /BUP goal	BUP days (planned)	Days	% up time	Comment
Au-Au	200	14.37 B	12 B	1.2	(70)	79	74	
d-Au Min bias	200	1.12 B	1 B	1.12	11 (7)	8	72	5% Central updated goal
<i>d-Au MPC trigger</i>	<i>200</i>	<i>73.4 /nb</i>	<i>[77] /nb</i>	<i>[0.95]</i>				<i>5% Central</i>
d-Au	62	285 M	230 M	1.22	11 (7)	6		5% Central
d-Au	39	90 M BBC, FVTX	110 M	0.81	14 (7)	7	71	5% Central (High background)
d-Au	20	8.6 M FVTX, BBC	7 M	1.14	14 (11)	8 [11]	69	5% Central Estimated from offline quick analyzes High background still under study

The causes of success

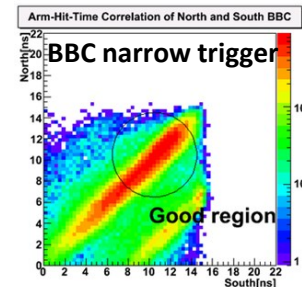
- [+] Not as high as sometimes expected, but a very good beam, despite of
- [-] IP2 restrictions (vacuum tube)
- [-] 20 GeV: special background pb
- [+] Quite a very good weather , not too hot, few storms
- [+] Energy price was « low »
- [-] 39GeV: not enough time [+] but compares with goal
- [-] 39 GeV should have been before 20 GeV
- [+] no prefire problem
- Conclusion: on the average, on top of good beam and good organisation, luck and good will were on the good side, allowing to compensate the loss of 2.5 weeks from magnet diode failure , and then to perform this dAu BES, despite being on lower priority. Background situation still under study at 20 GeV.

Lessons ? : Possible to do better (->[-] ? And Next slides)

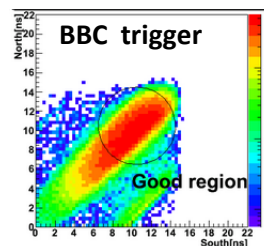
Back on 20GeV physics undeclared

- Thursday 26, CAD RC: 62->20 : change of period in RHIC 52 ns (%62)
- Friday 27 night 3AM: smoke alarm Repeatedly. Power crash button: total shutoff. Also automated inert gas release.
- [see details in following slides] ... det powered progressively (LV) up and gaz flowing around (8PM ?) [finally quite quick]
- Beam for BBC tuning ~3AM . -> ~Same tuning (?) but « bad » beam conditions
- Memorial day holidays up to Tuesday
- Saturday: BBC narrowvertex triggers looks quite ~good →
- FVTX trigger (experts travel), try understand events and background
- Saturday evening change of injection, collimation: **Most of the triggers (including ZDC) and counts were background.** Phenix cannot declare physics as long as events not checked.
- monday night: analysis show inconsistencies in triggers
- Tuesday: timing tuned again, 62 ns (+ MCR confirmation 70ns expected %200 GeV). Timing is finally established. (took ~3 days)
- Saturday: from 2 analyses, estimate of the number of usable events

Bad timing

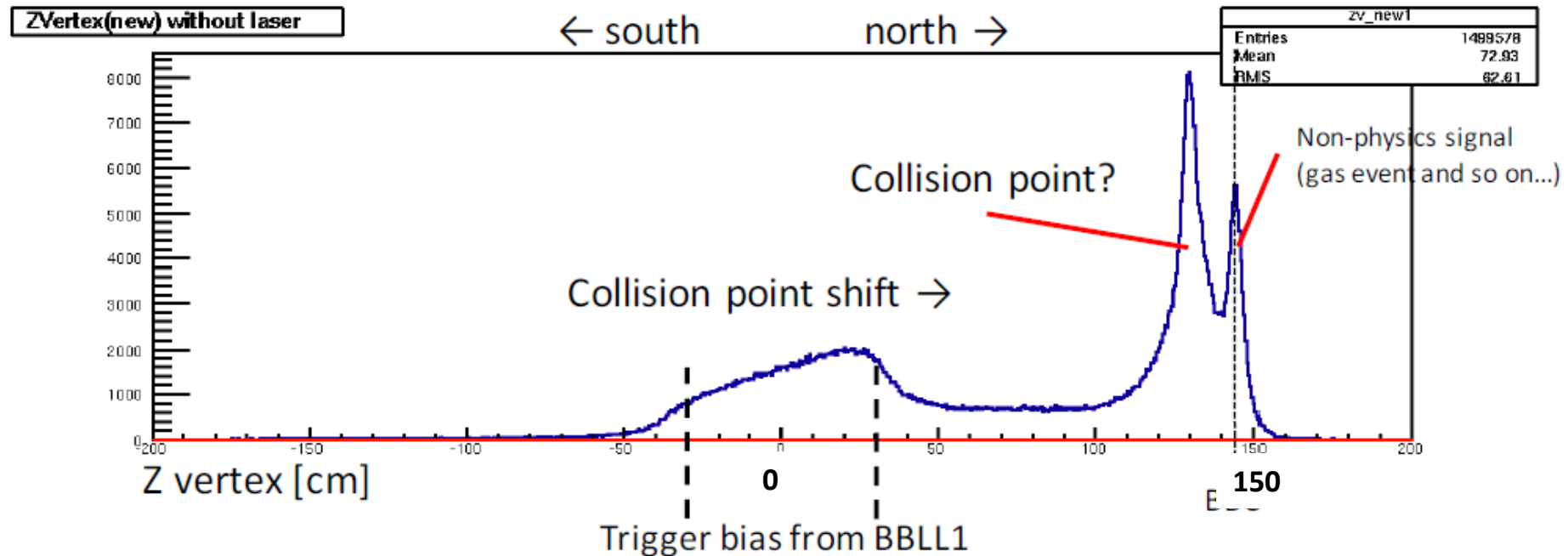


Good timing



background: still open questions

Run#: 456655, Trigger: all trigger



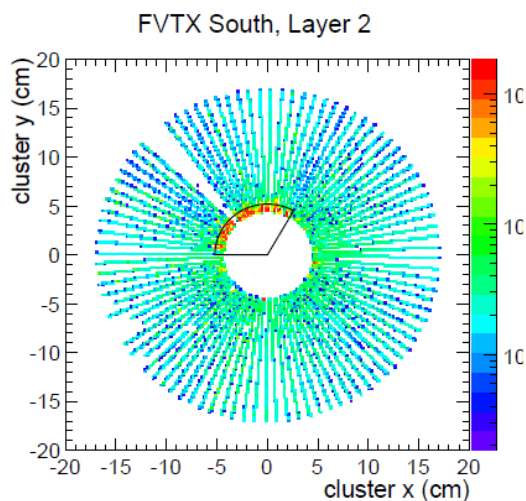
- In addition to collisions around $ZV=0$, there are peaks at large ZV
- There have been several hypotheses, but let's stick to one

About the 2 peaks

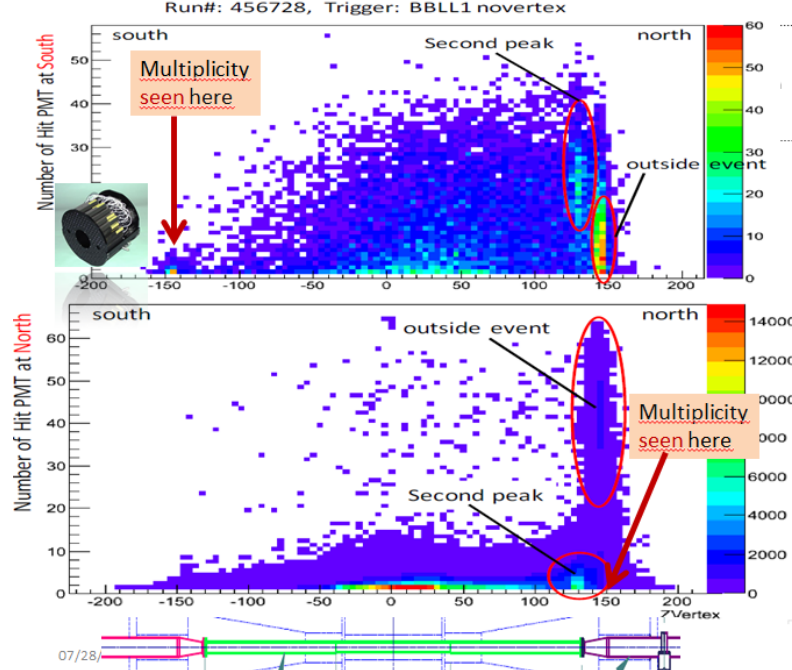
ZV=144: collision at ZV>144 (Au-d or Au gaz, etc) .
 Particles created upstream in yellow create signal in north BBC, then south. High multiplicity in north.

Very different pattern for
 ZV~130: collision at ZV=130 ? indeed there is a reduction of the beampipe here, and a flange.
 Most of produced particles go toward south BBC.
 Only one hit in the north (backward particle ?).

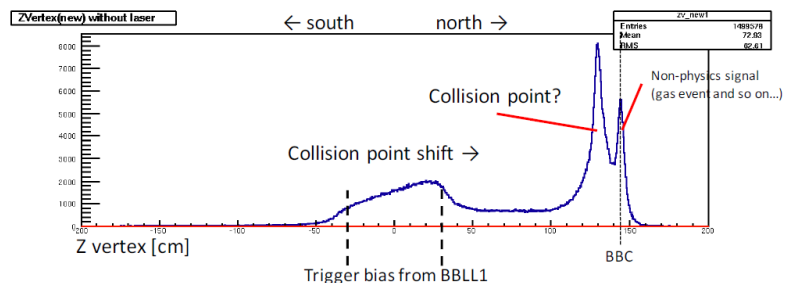
-30 < Z < 30 good collisions. High multiplicity in south



07/28/2016



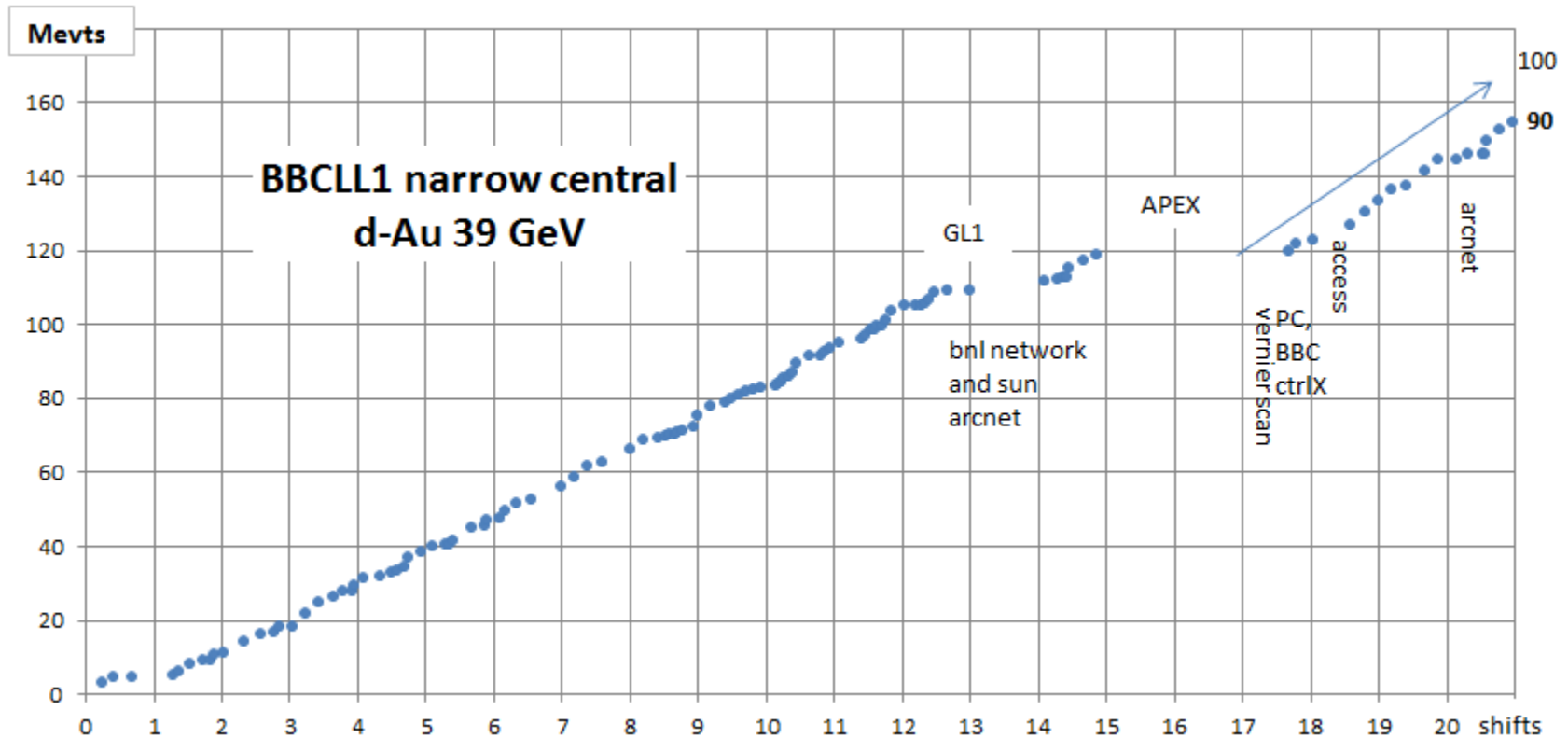
Run#: 456655, Trigger: all trigger



at analyses level , Background is still an issue and under study

d-Au 39 GeV: why missing BUP goal ?

- Problems occurred from Tuesday afternoon
- Thanks to uptime of beam and efficiency of data taking at the end, we made it to 90Mevts (but BUP goal 110Mevt)
- Nevertheless **Average DAQ uptime still 0.7**, despite of full shift lost.
- Conclusion: 2 shifts were missing to reach the goal
- But **BUP goal was for 2 weeks** , so **80% in one week is a success !**



Smoke Alarm Incident, May 27 2016

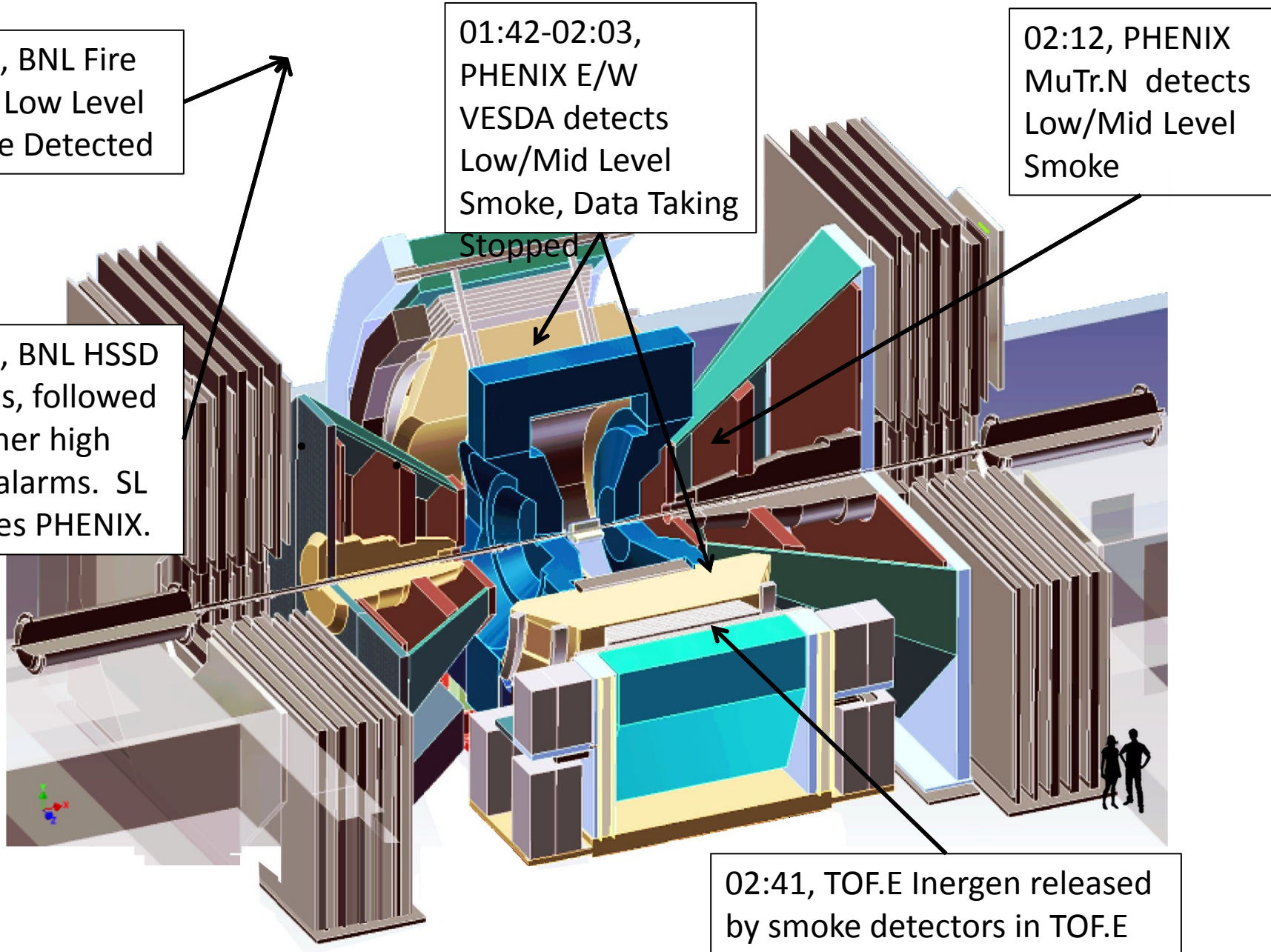
00:29, BNL Fire
HSSD Low Level
Smoke Detected

02:19, BNL HSSD
alarms, followed
by other high
level alarms. SL
crashes PHENIX.

01:42-02:03,
PHENIX E/W
VESDA detects
Low/Mid Level
Smoke, Data Taking
Stopped

02:12, PHENIX
MuTr.N detects
Low/Mid Level
Smoke

02:41, TOF.E Inergen released
by smoke detectors in TOF.E



Additional Info + Followup

- Data was being taken as initial low/mid level smoke alarms went off
 - No indication of problem with any subsystem in online monitor, though one might not notice a small number of channels going bad
- However, no rack smoke alarms went off, so source is external to racks (some, but not many of the PHENIX electronics are outside racks)
- BNL FD walked through entire IR right after incident and did not find a source
- Some definite facts:
 - Multiple independent alarms went off
 - BNL FD had to replace the BNL Zone 3 head, which appeared to be contaminated
 - IR air had to be changed
- In aftermath on Friday, worked closely with Fire Protection Engineer and Fire Marshall Joe Terranova to investigate cause before restoring PHENIX
- Investigation consistent with bring PHENIX back online (needed to energize systems in order to see if failure could be replicated)
- Walked down the entire IR a second time looking for evidence of smoke or fire damage, and hot spots using infrared camera, but found nothing
- Downtime without power enabled was not as long as expected due to hard work of everyone involved. 17 hours before Phenix full power reenabled: general downtime to physics limited to about 1 shift. Then phenix C_tracking -1day , tofE - 3 days
- *Cause of alarm currently still unknown...*

Lessons learned

(Wolfram requested some critics)

at least: are there areas where maybe we could do better, more efficient (get closer to goal), next time ?

These are more personal views than phenix collaboration statements

Internally in PHENIX (no next time but...)

- Very effective readiness process by BNL team (december, january)
- Very effective, reactive support and maintenance (including electronics, daq). They never sleep.
- Quick online analysis possible.
- Shift organisation: owl was too hard (0 to 8 AM). Miss incentive.
- Shift organisation: instructions allow team to react but maybe could save time by relying less on experts
- Minimizing accesses and downtime: continue looking for priority running when looking for solutions on a subsystem
- Reliability of power supplies is an important parameter
- Low energy background: more anticipation (tuning, monitoring, offline) and quick comparison to expectation, if possible, should be a must.
- In particular special timing process
- Tuning of timing preferably when good quality beam (but loops with optimization)
- Is it possible to distinguish Fire from smoke ?

With respect to CAD and BNL

- Very good beam, high luminosity, high rate at end of store
- Good organisation of exchange of information (meetings, logbooks, ...)
- Of course a lot to learn
- could benefit from a long term expertise inside phenix ? (quite frustrating to stop now)
- Also introductory documentation (focus, etc) is a good point
- Grouping accesses can save uptime
- A flexible organization (Monday maintenance day, tuning beam on week end, ..)
- very effective safety protection
- Burned toast: downtime avoidable ?
- Shutoff: impressive efficient recovering, quick without compromise on safety.
- Very useful to get the precise information of the total delay in the clock expected *at phenix*, for high background and broad time structure beam

possible improvement ?

- Because of increasing challenges with triggering and background, PHENIX requested to start with the highest beam energy and then progressively lower the energy, so that **the most challenging, the 20 GeV run, would have been last**. STAR requested to have the 20 GeV run earlier since it had higher priority for them. The STAR request was granted. We feel that STAR's overall physics program would not have been much at risk (and they finished sooner) if the 20 GeV run had been last while it had a real impact on PHENIX's ability to take data at 20 GeV.

In our opinion the decision should have been to go with the PHENIX proposal. It should have been better calendar on many accounts (memorial weekend also).

- IP2 Vacuum tube problem: we still don't understand how this problem could occur or **if it could have been prevented**



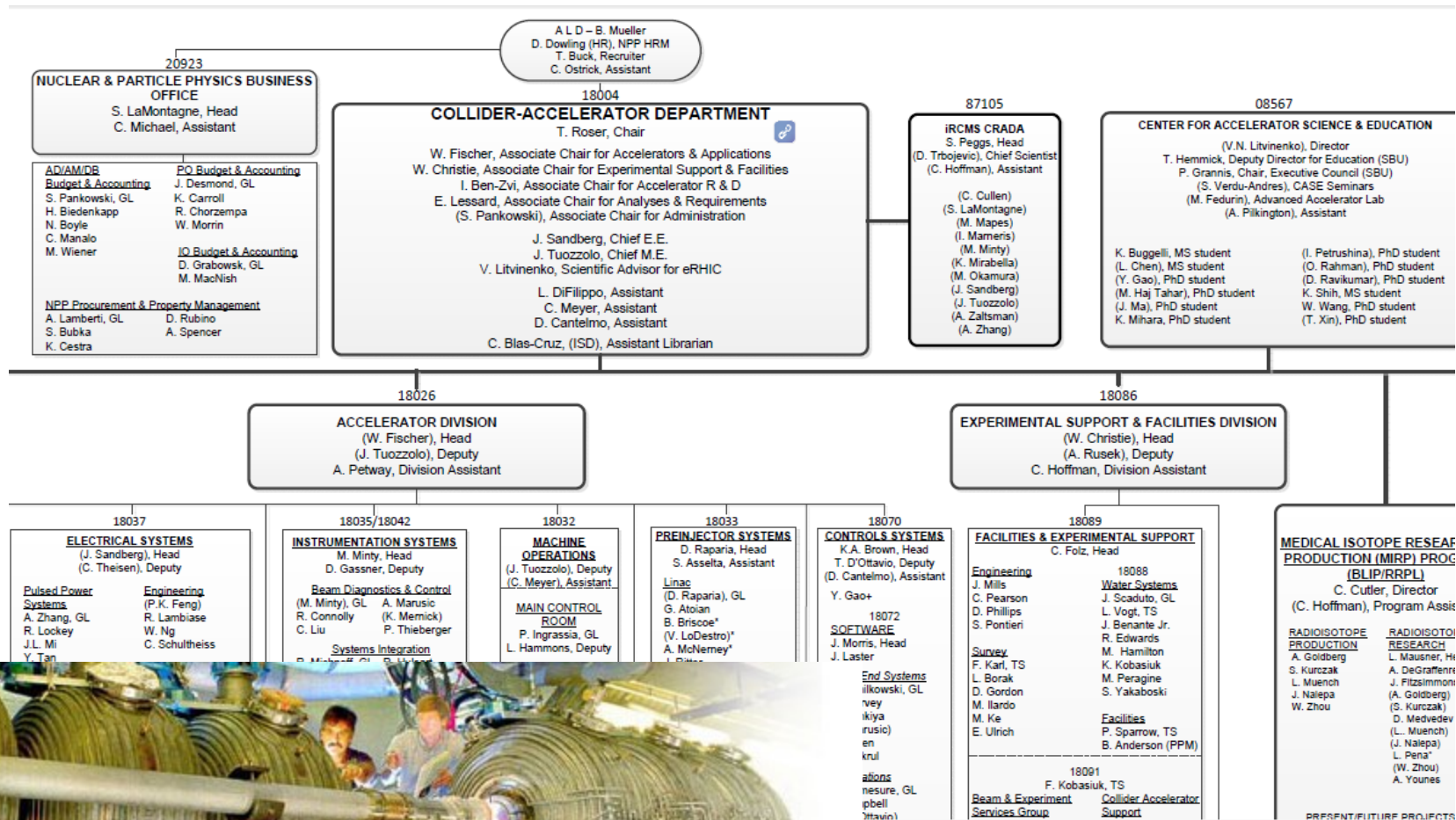
- In the case of CeC not being able to use the last week of the run as planned, it is important that a situation like this is determined as soon as possible (for instance if a cavity is known not being possibly ready) so that the other experiments can adjust to the new situation (experts from abroad, shift crews, etc.) We feel that the decision **could have perhaps been made sooner**.

Some uncomfortable questions

- The scheduling physicist treated equally experiments most of the time and did a great job to organise and optimize the activities. On some critical moments one could wonder if the Star run coordinator was taking the first role. It is a difficult exercise.
- One can also wonder if such a strong link between the scheduling physicist, head of the Experimental Support Division, and an experiment could influence the technical advices or involvements. For instance the interpretation of the PAC priorities was very strict in the proposed calendar. Also, The expected setting up times for change of beam seemed to fluctuate in the last weeks, looking correlated to the question of AuAu additional period length.
- Anyway it is good to have a BNL physicist at this position, active in an experiment. And the call to an upper independent authority is anyway needed when there is no consensus between experiments at this level. But one should probably at least look for organisational ways to avoid too much concentration and promote diversity.

Thanks to BNL, CAD, RHIC

- great beams , great collection of data, goals quite all fulfilled
- Thanks to all the services and in particular CAD



Summary

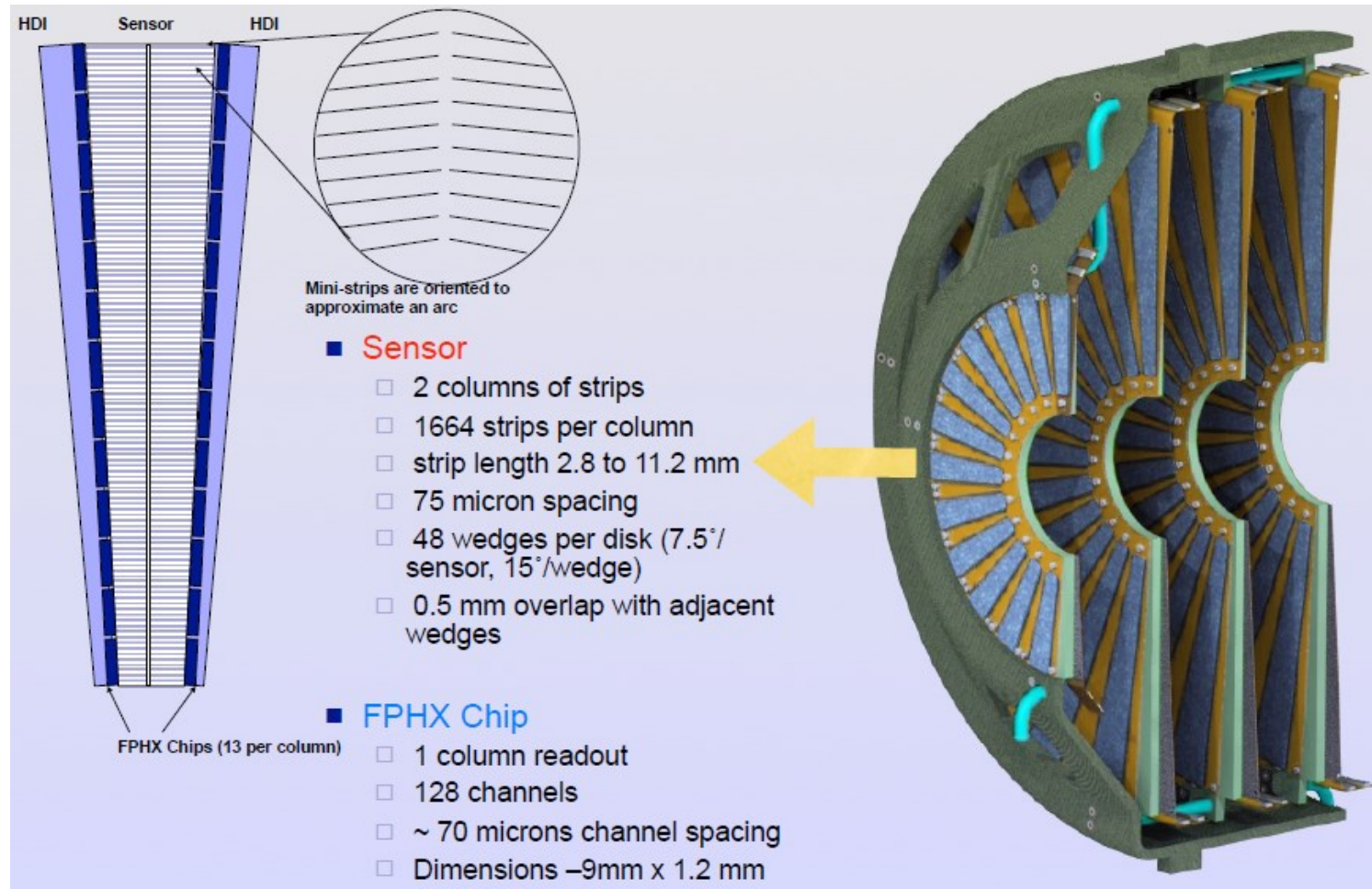
- Evolutive planning all along, plus one catastrophic event on the accelerator side, and a full protective shutoff of Phenix
- Despite the foreseen and unforeseen difficulties, very satisfactory outcome of run16, achieving AuAu 200 GeV and dAu BES very successfully
- We look forward for the results, and some challenge in analysis too, especially 20 GeV
- A lot of Thanks to the dedication and remarkable expertise of all the BNL and CAD services and people. Very beautiful collective work.

BACKUP

Could it be possible to avoid some time lost ?

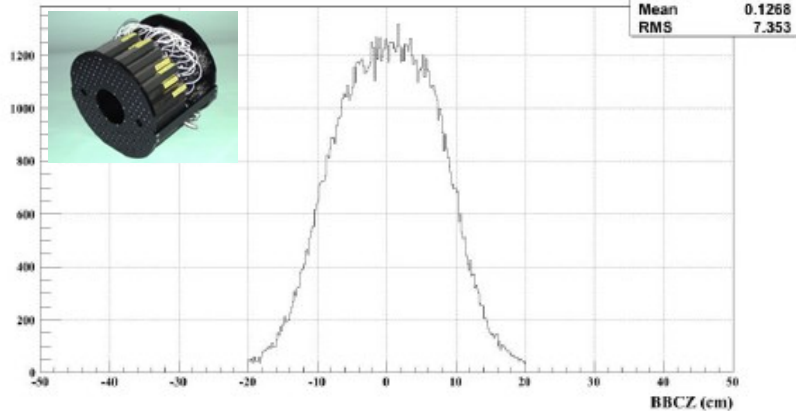
- A big chockoff of everything. Restart from zero or less.
- A new and more complex situation, unclear, and probably still
- Huge background, very small signal , triggers fooled
- Timing with too raw beam in high background situation [but bootstrap loop here ?]
- A long special week end
- We were not expecting so high background.
- There were mistakes we could have probably avoided. But as for security or safety, increasing probabilities and possibilities of mistake help them to appear. In that case, putting the 20 GeV at this time was taking an unnecessary risk (even if the initial plan did not really stress the interest of 200 -> 20 order ;=).

backup

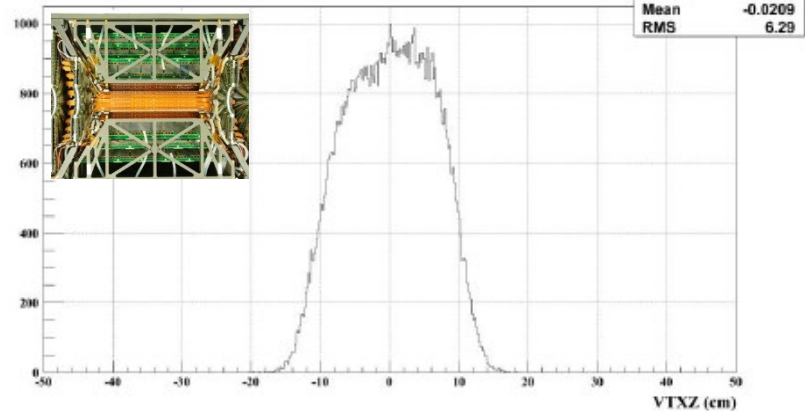


« ~On line » vertex

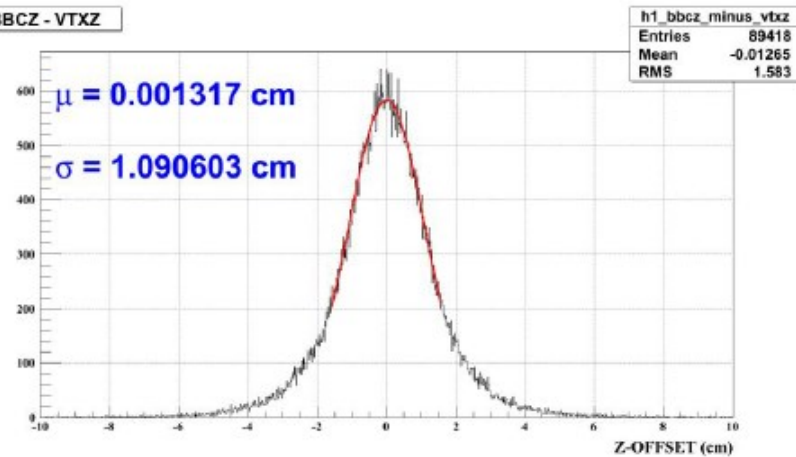
BBCZ



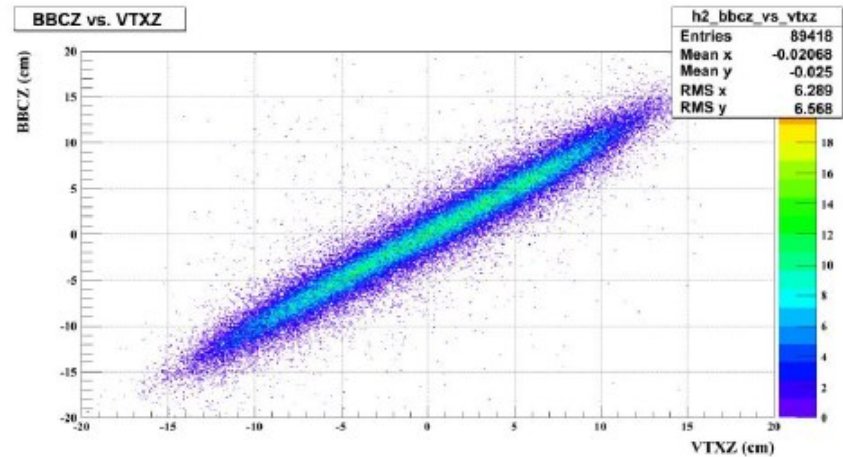
VTXZ



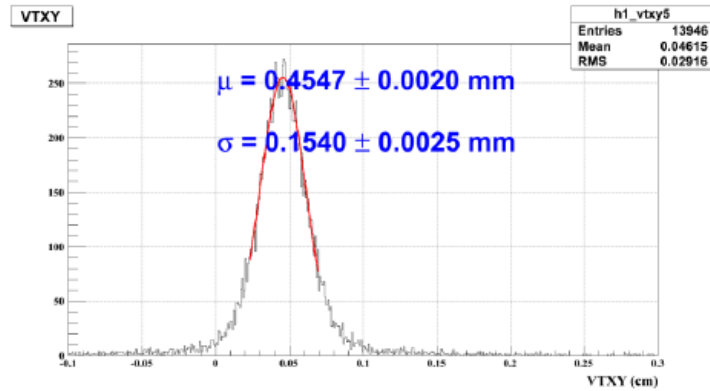
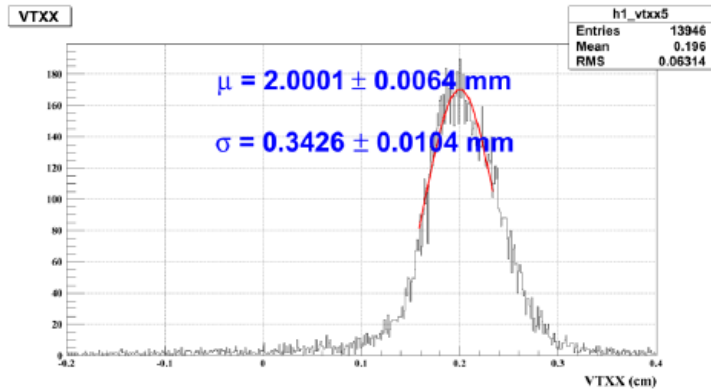
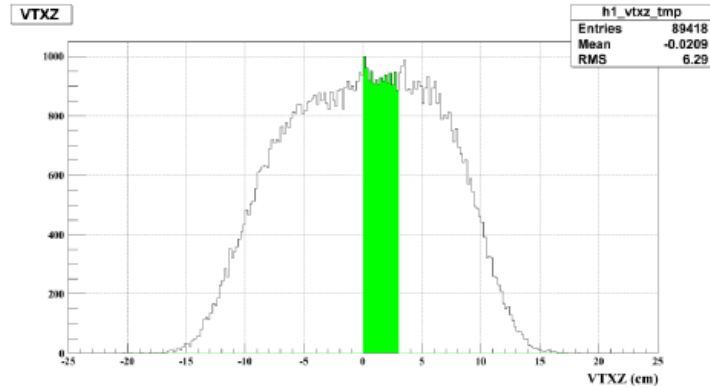
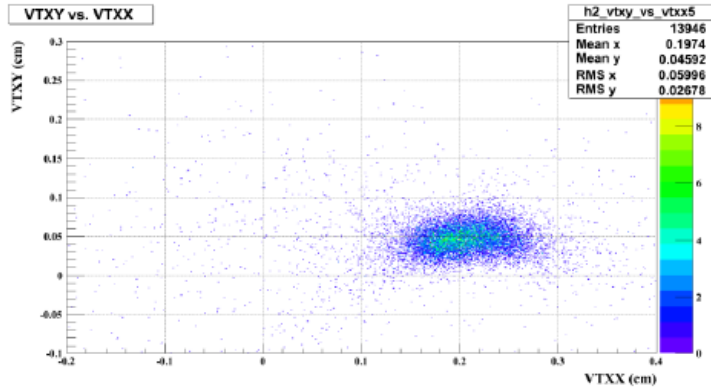
BBCZ - VTXZ



BBCZ vs. VTXZ



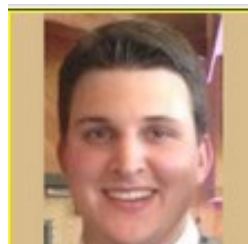
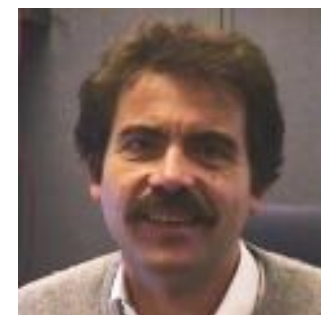
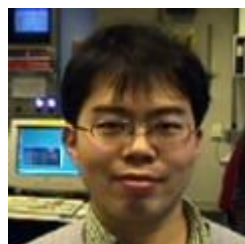
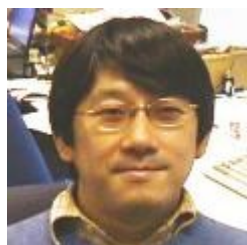
Trigger: MB



0 cm < VTXZ < 3 cm

Thanks to all shifters !!

Special thanks to the owl shifters !! (in phenix, 0-8AM)





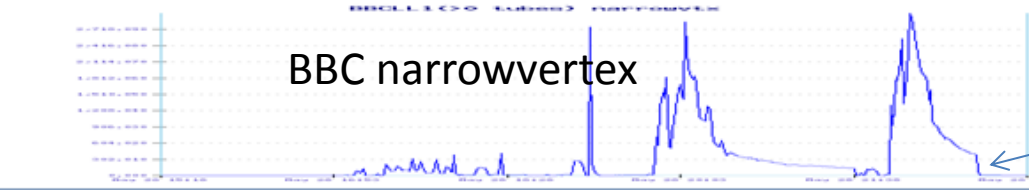
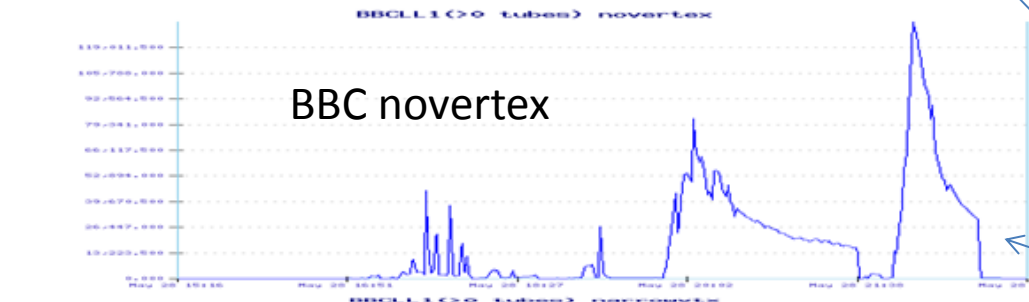
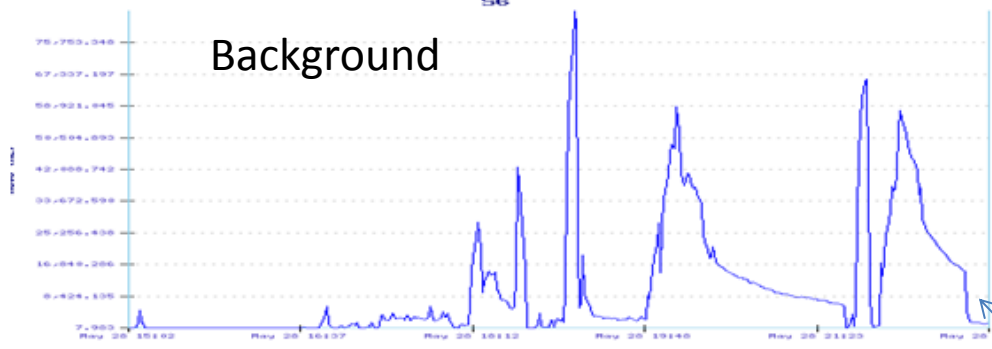
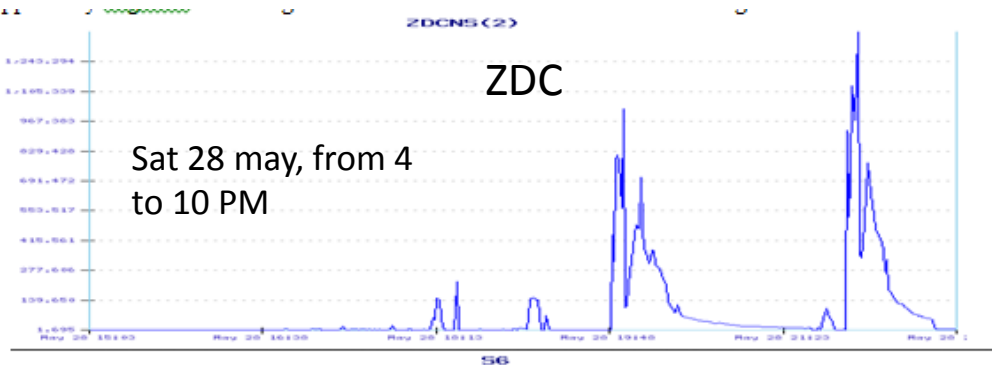
Thanks to the period coordinators



This year a deliberate attempt to include

- more women
- favor first experiences

coincidences very sensitive to background

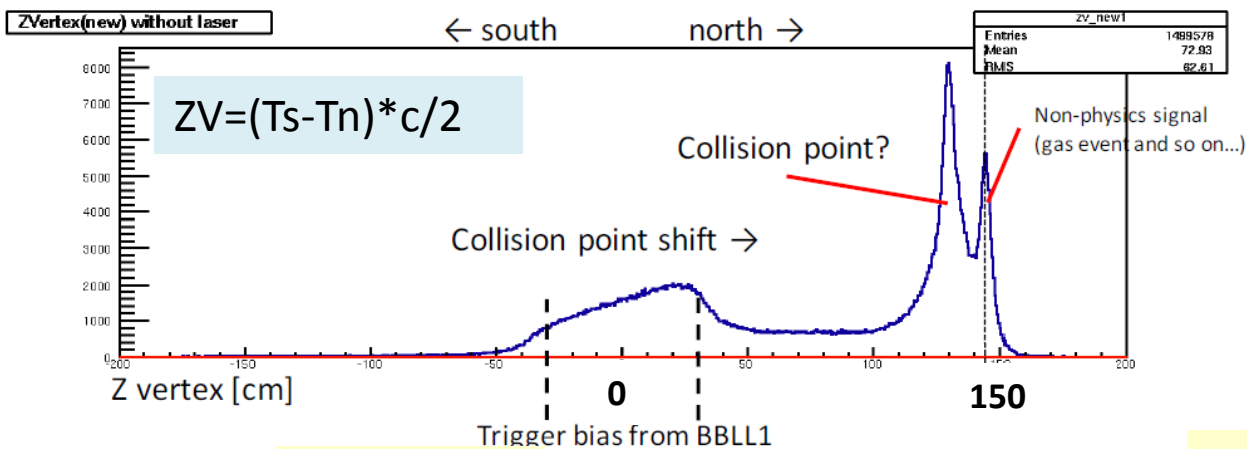


effect of
collimation
(Saturday
evening):
suppression of all
available signals

BBC Narrow vertex
500->10

This is not the
end of store

BBC zvertex distribution



Cerenkov detector
→ ~c

TS=9.62 ns

BBC S

TN=0

BBC N

→ ZV = 144.5 cm

All collisions outside +
-144.5 cm are
seen at +
-144.5cm

TS=9.1 ns

BBC S

→ ZV = 129 cm

TN=0.5 ns

BBC N

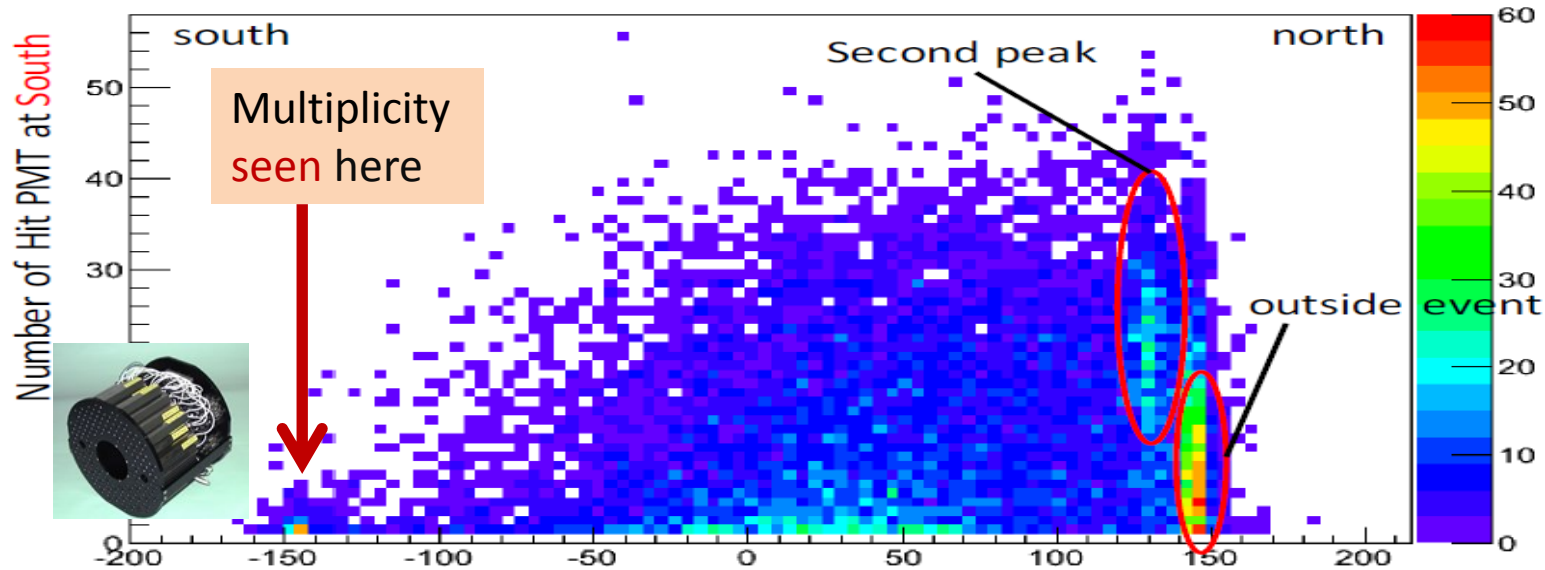
TS= 0 ns

BBC S

TN=9.6 ns

BBC N

→ ZV = - 144.5 cm



The peak at 130cm is probably a collision with North flange (high multiplicity in south)

